BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

PATENT SPECIFICATION (11) 1 391 575

1 391 575

(21) Application No. 8128/73 (22) Filed 19 Feb. 1973 (19)
(31) Convention Application No. 7 205 387 (32) Filed 17 Feb. 1971 in
(33) France (FR)
(44) Complete Specification published 23 April 1975
(51) INT. CL.² A61M 5/20 F04B 9/00
(52) Index at acceptance
A5R 33C1A
F1R 15C

(54) IMPROVEMENTS IN AND RELATING TO A MEDICAL INJECTION APPARATUS

(71) I, PAUL MASSY, a French citizen, of 17 Rue des Jalles, Merignac, Gironde, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a medical injection apparatus, particularly but not exclusively for radiological examination of the human blood circulation as well as that of animals.

Apparatus are known which permit injection, in accordance with a predetermined program, for example continuously or intermittently, of an opacifying liquid, into the blood vessels in order to produce a contrast permitting radiological examination of these vessels.

Such apparatus, for example as described in French Patent Specification No. 1,396,385, include at least one syringe mounted on a frame and a mechanism for driving the piston of this syringe, this mechanism being controllable in accordance with a predetermined program.

In one such apparatus, this mechanism includes pneumatic rams, which are not altogether satisfactory for vascular examination, because of very short injection periods (of the order of 3/10 of a second and even less in certain cases) and the starting inertia of the ram mechanisms.

In another such apparatus, the mechanism includes a screw and nut driven by a motor, the screw constituting a plunger of the syringe piston. Now, in the course of an injection, the acceleration and braking of the relatively large masses of these components do not allow for very short injection periods either.

According to the present invention there is provided medical injection apparatus comprising a syringe mounted on a frame, means for moving the piston of the syringe, a constant torque electric motor having an excitation circuit to be supplied with a constant direct current voltage and an armature circuit to be supplied with a voltage which is variable to vary the speed of the motor, the motor being connected by transmission means to the piston moving means, the transmission means including a nut and a threaded member interengaged by ball bearings, an electrical circuit for controlling the motor in accordance with a preset program for operating the syringe in accordance with a predetermined program, wherein the electrical circuit includes switching means for supplying the motor with a constant direct current excitation voltage and with an armature voltage dependent upon means for regulating the speed of the motor, the motor being provided with an electromagnetic braking means.

A relatively compact electric motor of the constant torque type can at present be constructed; such a motor can start with a very short time delay, of the order of a few thousandths of a second, while providing a remarkably large thrust.

Because of its electromagnetic nature, the brake incorporated in the motor can have a practically instantaneous effect overcoming the inertia of the armature of this motor, and thus ensuring immediate stoppage of an injection or, where several syringes are provided or being used, preventing the delivery of one syringe into another.

In a preferred embodiment the transmission means includes a speed reducer, e.g. a flexible non-slip belt which is engaged on two pulleys angularly fast respectively with the spindle of the motor and the threaded member of the transmission means, the two pulleys have suitable diameters for the required speed reduction.

Preferably, the belt has a toothed surface for engagement with suitable pullies.

Such transmission means have a small inertia at starting and braking during an injection; they are, moreover, remarkably silent and non-cumbersome.

Finally, the nut, threaded member and ball-bearings assembly of the transmission

means has a relatively low friction which also favours the rapid starting and stopping of injections.

The invention will be more fully understood from the following description of an embodiment thereof, given by way of example only, with reference to the accompanying drawing, in which:

Figure 1 shows in perspective an embodiment of apparatus in accordance with the invention;

Figure 2 shows the apparatus of Figure 1 schematically in longitudinal section;

Figure 3 shows the rear portion of the apparatus of Figure 1 schematically in cross section;

Figure 4 shows a detailed view of a portion of Figure 2 in longitudinal section and on an enlarged scale; and

Figure 5 is a circuit diagram for the electrical apparatus shown in Figure 2.

The apparatus shown in Figure 1 comprises two syringes 1*d* and 1*g*, which are identical and arranged parallel to each other on the forward portion of a rigid plate 2*a* which forms the top of a parallelpipedic box 2. The box is carried by a support with orientatable means 3 which permit various positions, particularly a vertical position (necessary for the superimposition of products to be injected of different densities) to be assumed by the box.

The dimensions of these syringes are specified as adapted to the requirements of medical injections for vascular examination by radiology, and it will be noted that they are arranged in the longitudinal direction of box 2.

Two tubular elements 4*d* and 4*g* are mounted, parallel to each other, above plate 2*a*. Each of these elements is arranged coaxially with the axis of the piston rod 1*t* of a corresponding syringe and behind the latter.

A lateral surface of the box is provided with a panel 2*b* which has levers, switches or buttons 5, 5*a* and 5*b* and control keys 6 which will be mentioned again below.

Figure 2 also shows plate 2*a*, syringe 1*g* and the element 4*g* which is aligned with the rod 1*t* of this syringe 1*g*.

The other syringe 1*d* is not visible in Figure 2; the same is true of the apparatus and arrangements associated with element 4*d*. Only the apparatus and arrangements associated with element 4*g* will be described: element 4*d* is provided with identical apparatus which are partially visible in Figure 3.

Element 4*g* consists of a tubular section which is engaged, with slight friction, in a "Teflon" (Trade Mark) ring 7*g* which is suitably mounted in a hole provided in a rigid plate 7; the latter extends perpendicularly to plate 2*a* and transversely to syringe rod 1*t* so that the ring 7*g* forms a low friction bearing.

Tubular element 4*g* is arranged to operate as a plunger against the end of rod 1*t*, and is provided with a plug 4*p* on its end facing the end of this rod 1*t*.

The other end of tubular element 4*g* is rigidly connected to a nut 8 (Figure 4) in which is engaged a threaded portion of a rod 9, the other portion of which is mounted in a conventional bearing 10 and is provided with a pulley 11 (Figure 3); the bearing 10 is fixed on plate 2*a*.

The nut 8 is rigidly connected to a U-shaped bracket 8*b* which is engaged on a longitudinal rod 8*a* to prevent rotation of the element 4*g*, connected with this nut 8.

In addition, pulley 11 drives a belt 12 having transverse teeth and engaged on another pulley 13 of the same type.

This pulley 13 is mounted on a shaft 14, which is supported in a bearing 14*a* rigidly connected to plate 2*a*; this shaft 14 is connected to the end of the spindle of an electric motor 15, the leads 15*a* of which are suitably connected to a switching apparatus 16, which is itself connected to a normal electrical supply circuit, for example at 220 volts and 50 cycles.

It will be understood that belt 12 and the two pulleys 11 and 13 constitute means for transmitting the power of motor 15 to plunger 4*g*, by means of nut 8 and rod 9 to operate rod 1*t* of syringe 1*g*, the diameters of pullies 11 and 13 being different from each other and selected as a function of the torque to be transmitted. These pullies and belt form means for reducing the drive speed of rod 9. The belt 12 could be replaced by another endless flexible element, e.g. a chain, which positively engages rotatable elements on the rod 9 and shaft 14 to drive rod 9 without slip.

A transmission means 17, similar to means 11 to 13, enables a tachyometric dynamo 18 to be driven without slip from drive shaft 14; pulleys 17*a* and 17*b* of transmission means 17 also have suitable diameters for reduction of this speed of shaft 14 in an *ad hoc* ratio. In addition, the armature of this dynamo 18 is suitably connected, by wires 18*a*, to the switching apparatus 16, and the latter is provided with a potentiometer 19.

Figure 4 shows in detail the threaded portion of rod 9 and nut 8 which cause translation of plunger 4*g*. The thread of rod 9 is defined by a recess whose section is an arc of circle and in which ball-bearings 8*d* are received. The ball bearings are also engaged in a correspondingly shaped recess defining the threads in nut 8; these ball bearings thus form a helicoidal race, the two ends of which are connected in known manner by means of a system of return passages 8*c* provided in the body of nut 8.

Motor 15 is of the constant torque type, supplied with d.c., and the speed of which is variable by regulating the supply voltage of its armature.

The excitation circuit E (Figure 5) of motor 15 is supplied with a constant d.c. voltage from a voltage regulating means 15*e* provided in switching apparatus 16 and supplied with 50 c/s a.c. by a transformer T_1. The armature circuit I is independent of the excitation circuit E and can be supplied separately with a d.c. voltage by the switching apparatus 16. This supply to circuit I is regulated by a voltage regulator 16*i* which includes the potentiometer 19 controlled by one of the switches 5 for varying the voltage supplied to circuit I. Regulator 16*i* is also connected by wires 18*a* to the output of tachyometric dynamo 18 which supplies current to circuit I in dependence on the speed of motor 15.

Finally, an electromagnetic armature brake circuit F is incorporated in motor 15, the brake circuit being independent of the excitation and armature circuits E, I of the motor. The circuit F is supplied with a constant current by voltage regulating means 15*f* of switching apparatus 16, voltage regulating means 15*f* being supplied with a.c. voltage by a transformer T_2.

It will be noted that a motor of this type can be made in a compact size, approximately 20 cm by 8 cm in diameter, and having the characteristics indicated in the table below:

Excitation circuit	
Excitation voltage	110 volts
Power dissipated	25 watts
Armature circuit	
Adjustable supply voltage	110 volts to 2 volts
Supply current	9 a
Motor torque	2.5 Nm
Speed	3,200 rpm for a supply voltage of 110 volts
	2,150 rpm for a supply voltage of 75 volts
Electromagnetic brake circuit	
Supply voltage	24 volts
Braking torque	more than 2.4 Nm

The voltage indicated in this table are provided by switching apparatus 16 when the latter is supplied at 220 volts and 50 cycles. Such a motor can start very quickly, in less than 1/100 second, and reach its maximum torque in a few milliseconds.

The switching apparatus 16 includes a logic circuit 16*l* including relays and electronic elements, such as thyristors, which are interconnected to form circuits permitting various working programs for the syringes, the working programs being similar to those described in the French Patent Specification referred to above.

The circuit 16*l* is connected to mechanical timing devices e.g. 16*m*, formed for example by a friction motor. One of these timing devices may provide a delay between the operation of the plungers of two syringes. Another timing device, of a similar nature, may provide a delay between the actuation of an injection operation and that of the radiological apparatus, as described in the French Patent Specification referred to above.

Apparatus 16 also includes an electronic timing device 16*e* connected to circuit 16*l* and which enables the duration of an injection to be regulated; the value of this duration may be from 0.1 to 0.9 seconds or from 1 to 9 seconds.

A working program for two syringes may be selected for example by means of keys 6 on panel 2*b*; plungers 4*d* and 4*g* of the pistons of the syringes can be operated and stopped practically instantaneously.

Button 5 for control of potentiometer 19 can be manipulated to adjust the speed of the motor of each syringe, to obtain a predetermined injection flow rate.

The buttons which control the electronic timing device can be manipulated to precisely adjust the duration of an injection.

Finally, an electrical resistance device 2*c* (shown in Figure 5 and in broken lines in Figure 2) may be arranged on plate 2*a* to warm syringes 1*d* and 1*g*; this device 2*c* is connected by wires to the supply source of switching apparatus 16 and to a control button on panel 2*b*.

By means of such a device 2*c*, it is possible to warm the liquid in the syringes, for example, to make it more fluid or to bring it to the temperature of the human body.

WHAT I CLAIM IS:—

1. Medical injection apparatus comprising a syringe mounted on a frame, means for moving the piston of the syringe, a constant torque electric motor having an excitation circuit to be supplied with a constant direct current voltage and an armature circuit to be supplied with a voltage which is variable to vary the speed of the motor, the motor being connected by transmission means to the piston moving means, the transmission means including a nut and a threaded member interengaged by ball bearings, an electrical circuit for controlling the motor in accordance with a preset program for operating the syringe in accordance with a predetermined program, wherein the electrical circuit includes switching means for supplying the motor with a constant direct current excitation voltage and with an armature volt-

age dependent upon means for regulating the speed of the motor, the motor being provided with an electromagnetic braking means.

2. Apparatus according to claim 1, including a second syringe mounted on the frame, second means for moving the piston of the second syringe and a second constant torque motor connected by a second transmission means to the means for moving the piston of the second syringe, the circuit controlling the second motor.

3. Apparatus according to either claim 1 or claim 2, wherein the or each transmission means includes a flexible endless element engaged round two members angularly fast, respectively, with the spindle of the, or the respective, motor and with the threaded member of the corresponding transmission means.

4. Apparatus according to claim 3, wherein the diameters of the rotatable members of the or each transmission means are such as to provide a reduction of the speed of rotation of the corresponding motor.

5. Apparatus according to any preceding claim, wherein the or each means for regulating the speed of the motor include a tachyometric dynamo arranged to be driven, without slip, by the or the respective motor and connected to the switching means for regulating the voltage supplied to the armature circuit of the said motor.

6. Apparatus according to claim 5, wherein the switching means includes an electronic timing device for adjusting the duration of an injection made by the or the respective syringe.

7. Apparatus according to any preceding claim, including means for heating the or each syringe.

8. Medical injection apparatus substantially as herein described with reference to the accompanying drawings.

A. A. THORNTON & CO.,
Northumberland House,
303—306 High Holborn,
London, W.C.1.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1975.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1391575 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

Fig.1

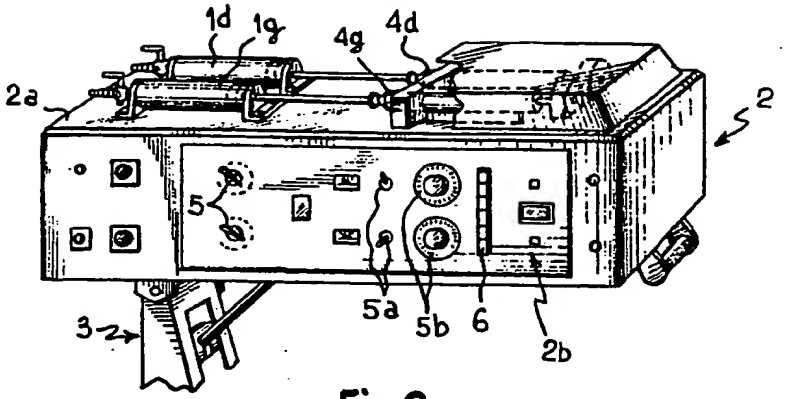

Fig.2

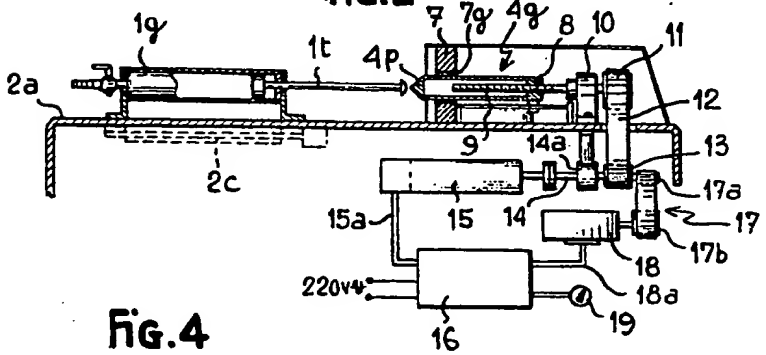

Fig.4

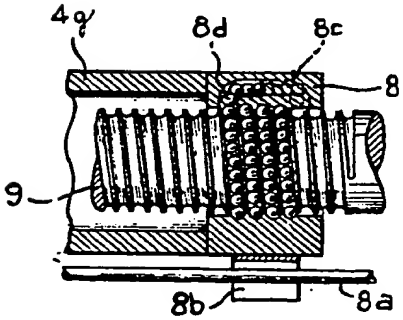

Fig.3

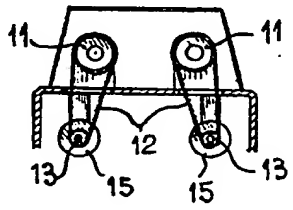

FIG.5